

PATENT COOPERATION TREATY

PCT

NOTIFICATION CONCERNING
DOCUMENT TRANSMITTED

From the INTERNATIONAL BUREAU

To:

United States Patent and Trademark
Office
(Box PCT)
Crystal Plaza 2
Washington, DC 20231
ÉTATS-UNIS D'AMÉRIQUE

in its capacity as designated Office

Date of mailing (day/month/year)

23 June 1999 (23.06.99)

International application No.

PCT/GB97/03507

International filing date (day/month/year)

19 December 1997 (19.12.97)

Applicant

SCHLUMBERGER CANADA LIMITED et al

The International Bureau transmits herewith the following documents and number thereof:

_____ cop(ies) of priority document(s) (Rule 17.2(a))

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer

H. Zhou

Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION CONCERNING
SUBMISSION OR TRANSMITTAL
OF PRIORITY DOCUMENT

(PCT Administrative Instructions, Section 411)

To:

STOOLE, Brian, David
Geco-Prakla Technical Services Inc.
Schlumberger House
Buckingham Gate
Gatwick, West Sussex RH6 0NZ
ROYAUME-UNI

Date of mailing (day/month/year) 23 June 1999 (23.06.99)	IMPORTANT NOTIFICATION
Applicant's or agent's file reference 14.0088	
International application No. PCT/GB97/03507	International filing date (day/month/year) 19 December 1997 (19.12.97)
International publication date (day/month/year) 02 July 1998 (02.07.98)	Priority date (day/month/year) 20 December 1996 (20.12.96)
Applicant SCHLUMBERGER CANADA LIMITED et al	

1. The applicant is hereby notified of the date of receipt (except where the letters "NR" appear in the right-hand column) by the International Bureau of the priority document(s) relating to the earlier application(s) indicated below. Unless otherwise indicated by an asterisk appearing next to a date of receipt, or by the letters "NR", in the right-hand column, the priority document concerned was submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b).
2. This updates and replaces any previously issued notification concerning submission or transmittal of priority documents.
3. An asterisk(*) appearing next to a date of receipt, in the right-hand column, denotes a priority document submitted or transmitted to the International Bureau but not in compliance with Rule 17.1(a) or (b). In such a case, **the attention of the applicant is directed** to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.
4. The letters "NR" appearing in the right-hand column denote a priority document which was not received by the International Bureau or which the applicant did not request the receiving Office to prepare and transmit to the International Bureau, as provided by Rule 17.1(a) or (b), respectively. In such a case, **the attention of the applicant is directed** to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

<u>Priority date</u>	<u>Priority application No.</u>	<u>Country or regional Office or PCT receiving Office</u>	<u>Date of receipt of priority document</u>
20 Dec 1996 (20.12.96)	9626442.9	GB	15 June 1999 (15.06.99)

The International Bureau of WIPO
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1211 Geneva 20, Switzerland

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PATENT COOPERATION TREATY

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NOTIFICATION OF THE RECORDING
OF A CHANGE(PCT Rule 92bis.1 and
Administrative Instructions, Section 422)

From the INTERNATIONAL BUREAU

To:

STOOLE, Brian, David
Geco-Prakla Technical Services Inc.
Schlumberger House
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Gatwick, West Sussex RH6 0NZ
ROYAUME-UNI

Date of mailing (day/month/year)

26 April 1999 (26.04.99)

Applicant's or agent's file reference

14.0088

IMPORTANT NOTIFICATION

International application No.

PCT/GB97/03507

International filing date (day/month/year)

19 December 1997 (19.12.97)

1. The following indications appeared on record concerning:

☒ the applicant ☐ the inventor ☐ the agent ☐ the common representative

Name and Address

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Norway

State of Nationality

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State of Residence

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Telephone No.

Facsimile No.

Teleprinter No.

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

☒ the person ☐ the name ☐ the address ☐ the nationality ☐ the residence

Name and Address

SCHLUMBERGER HOLDINGS LIMITED
P.O. Box 71
Craigmuir Chambers
Road Town
Tortola, British Virgin Islands
Virgin Islands, British

State of Nationality

**

State of Residence

**

Telephone No.

Facsimile No.

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3. Further observations, if necessary:

The applicant indicated in Box 2 is applicant for all designated States except CA, FR and US.

4. A copy of this notification has been sent to:

☒ the receiving Office ☐ the designated Offices concerned
☐ the International Searching Authority ☒ the elected Offices concerned
☐ the International Preliminary Examining Authority ☐ other:

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Norway

State of Nationality

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Facsimile No.

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2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

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3. Further observations, if necessary:

The applicant indicated in Box 2 is applicant for FR only.

4. A copy of this notification has been sent to:

☒ the receiving Office ☐ the designated Offices concerned
☐ the International Searching Authority ☒ the elected Offices concerned
☐ the International Preliminary Examining Authority ☐ other:

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ROYAUME-UNI

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26 March 1999 (26.03.99)

Applicant's or agent's file reference

14.0088

IMPORTANT NOTIFICATION

International application No.

PCT/GB97/03507

International filing date (day/month/year)

19 December 1997 (19.12.97)

1. The following indications appeared on record concerning:



the applicant



the inventor



the agent



the common representative

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2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:



the person



the name



the address



the nationality



the residence

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24th floor
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Canada

State of Nationality

CA

State of Residence

CA

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3. Further observations, if necessary:

The applicant indicated in Box 2 is applicant for CA only.

4. A copy of this notification has been sent to:



the receiving Office



the designated Offices concerned



the International Searching Authority



the elected Offices concerned



the International Preliminary Examining Authority



other:

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1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

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**NOTIFICATION OF THE RECORDING
 OF A CHANGE**

(PCT Rule 92bis.1 and
 Administrative Instructions, Section 422)

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To:

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Applicant's or agent's file reference 14.0088	
International application No. PCT/GB97/03507	International filing date (day/month/year) 19 December 1997 (19.12.97)

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☒ the applicant ☐ the inventor ☐ the agent ☐ the common representative

Name and Address

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 Norway

State of Nationality

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State of Residence

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Name and Address

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 42, rue Saint-Dominique
 F-75007 Paris
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State of Nationality

FR

State of Residence

FR

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Facsimile No.

Teleprinter No.

3. Further observations, if necessary:

The applicant indicated in Box 2 is applicant for AT, BE, CH and LI, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE.

4. A copy of this notification has been sent to:

☒ the receiving Office ☐ the designated Offices concerned
☐ the International Searching Authority ☒ the elected Offices concerned
☐ the International Preliminary Examining Authority ☐ other:

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Authorized officer

H. Zhou

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PATENT COOPERATION TREATY

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NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

United States Patent and Trademark
Office
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ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year)

04 August 1998 (04.08.98)

International application No.

PCT/GB97/03507

Applicant's or agent's file reference

14.0088

International filing date (day/month/year)

19 December 1997 (19.12.97)

Priority date (day/month/year)

20 December 1996 (20.12.96)

Applicant

BITTLESTON, Simon, Hastings

1. The designated Office is hereby notified of its election made:

☒ in the demand filed with the International Preliminary Examining Authority on:

03 July 1998 (03.07.98)

☐ in a notice effecting later election filed with the International Bureau on:

2. The election ☒ was

☐ was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO
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C. Cupello

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PATENT COOPERATION TREATY

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26 March 1999 (26.03.99)

Applicant's or agent's file reference

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IMPORTANT NOTIFICATION

International application No.

PCT/GB97/03507

International filing date (day/month/year)

19 December 1997 (19.12.97)

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☒ the person ☐ the name ☐ the address ☐ the nationality ☐ the residence

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Teleprinter No.

3. Further observations, if necessary:

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4. A copy of this notification has been sent to:

☒ the receiving Office ☐ the designated Offices concerned
☐ the International Searching Authority ☒ the elected Offices concerned
☐ the International Preliminary Examining Authority ☐ other:

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PATENT COOPERATION TREATY

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REC'D 05 FEB 1999

WIPO PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 14.0088	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (PCT/IPEA/416)	
International application No. PCT/GB97/03507	International filing date (day/month/year) 19/12/1997	Priority date (day/month/year) 20/12/1996
International Patent Classification (IPC) or national classification and IPC G01V1/38		
Applicant GECO AS et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.



2. This REPORT consists of a total of 6 sheets, including this cover sheet.

- ☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☒ Certain documents cited
- VII ☒ Certain defects in the international application
- VIII ☒ Certain observations on the international application

Date of submission of the demand 03/07/1998	Date of completion of this report 03.02.99
Name and mailing address of the IPEA/  European Patent Office D-80298 Munich Tel. (+49-89) 2399-0, Tx: 523656 epmu d Fax: (+49-89) 2399-4465	Authorized officer Kys, E Telephone No. (+49-89) 2399-6513 

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/GB97/03507

I. Basis of the report

1. This report has been drawn on the basis of (*substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments.*):

Description, pages:

1-7 as originally filed

Claims, No.:

1-13 as originally filed

Drawings, sheets:

1/2-2/2 as originally filed

2. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
☐ the claims, Nos.:
☐ the drawings, sheets:

3. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

4. Additional observations, if necessary:

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/GB97/03507

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes: Claims 1-12
	No: Claims 13
Inventive step (IS)	Yes: Claims 1-12
	No: Claims 13
Industrial applicability (IA)	Yes: Claims 1-13
	No: Claims

2. Citations and explanations

see separate sheet

VI. Certain documents cited

1. Certain published documents (Rule 70.10)

and / or

2. Non-written disclosures (Rule 70.9)

see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/GB97/03507

SECTION V -----

A. CITATIONS (for certain published documents, see point VI. below)

The documents below of the International search report are considered:

D3= US,A,3 774 570; **D5=** EP,A,0 193 215;

D4= US,A,5 443 027; **D6=** US,A,4 745 583.

B. EXPLANATIONS (for clarity, see point VIII. below)

Both independent **claims 1 and 13** relate to a control device for controlling the depth of a marine seismic streamer.

1 Novelty in the sense of Article 33(1), (2) PCT

All cited documents relate to a control device for controlling the depth of a marine seismic streamer. Yet only the streamer of a certain published document D1 comprises the control means (311-314 in D1, Fig.4) as defined in **claim 1**, refer to point VI. below. Moreover, **claim 13** appears to comprise any control device known from the cited prior art, "being substantially" for controlling the position of a streamer, refer to point VIII. below.

Hence, the control device of claim 1 appears to be novel under the condition that D1 may be disregarded (see point VI below), and insofar clear (see point VIII below) in contrast to that of claim 13.

2 Inventive step in the sense of Article 33(1), (3) PCT

Except for D1, the available prior art does not hint at control means as claimed, ie whereby both the lateral and depth position of the streamer is controlled, see specially D2, col.1, ll.3-11; D3, col.1, ll.6-16; D4, col.3, ll.25-36; D5, last paragraph; D6, col.1, ll.9-16. Although a lateral control per se may be considered standard with respect, eg, to some paravane, it would appear to be the result of an ex-post facto analysis to arrive at the control device starting from the paravane (15 in D3, Fig.1) known from the present prior art.

Therefore, subject to the relevance of D1 the device of claim 1 appears to be non-obvious.

SECTION VI -----

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/GB97/03507

The documents below of the International search report have been introduced:

D1= WO,A,97 30361 (publ.: 21 August 1997);

D2= US,A,5 619 474 (publ.: 8 April 1997);

The present application has been filed on 19.12.1997, claiming a priority date of 20.12.1996. Hence, D1 and D2 might be disregarded as set out in **Rule 17.1(a), (b) PCT**.

However, if the claimed priority claim may be disregarded as set out in **Rule 17.1(c) PCT**, D1 appears to be the most relevant document cited in the search report, for the following reason:

The streamer of D1 comprises control means (311-314 in D1, Fig.4) for independently adjusting the respective angular positions of two control surfaces (302, 303 in D1, Fig.4) so as to additionally control the lateral position of the streamer as well (103 in D1, Fig.1), see specially D1, p.7, II.2-32. Since D1 also indicates the remaining features of claim 1, namely a body (301 in D1, Fig.4) with sensor means therein, see D1, p.8, I.33 - p.9, I.2, **the control device of claim 1 cannot be considered novel in view of D1.**

SECTION VII -----

- 1 **Claim 1** is not in the two-part form in accordance with **Rule 6.3(b) PCT**, with those features known in combination from the prior art being placed in a preamble (**Rule 6.3(b)(i) PCT**) and with the remaining features being included in a characterising part (**Rule 6.3(b)(ii) PCT**). In addition, it is not ensured that it is clear from the description which features of the subject-matter of **claim 1** is known from what document, in contrast to the **PCT Guidelines PCT/GL/3 III, 2.3a**.
- 2 The features of the claims are not provided with reference signs placed in parentheses (**Rule 6.2(b) PCT**).

SECTION VIII -----

Independent **claim 13** defines a control device only by references to the description and the drawings. According to **Rule 6.2(a) PCT**, however, claims should not contain such references except where absolutely necessary, which is not the case here. In

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/GB97/03507

addition, by just defining "the device [as] being substantially as herein described with respect of Figures ..." it is not clear which features delimit the claimed control device in view of the prior art.

CONTROL DEVICES FOR CONTROLLING THE POSITION OF A MARINE SEISMIC STREAMER

This invention relates to control devices for controlling the position of a marine seismic streamer.

A marine seismic streamer is an elongate cable-like structure, typically up to several thousand metres long, which contains arrays of hydrophones and associated electronic equipment along its length, and which is used in marine seismic surveying. In order to perform a 3D marine seismic survey, a plurality of such streamers are towed at about 5 knots behind a seismic survey vessel, which also tows one or more seismic sources, typically air guns. Acoustic signals produced by the seismic sources are directed down through the water into the earth beneath, where they are reflected from the various strata. The reflected signals are received by the hydrophones, and then digitised and processed to build up a representation of the earth strata in the area being surveyed.

The streamers are typically towed at a constant depth of about ten metres, in order to facilitate the removal of undesired "ghost" reflections from the surface of the water. To keep the streamers at this constant depth, control devices known as "birds", attached to each streamer at intervals of 200 to 300 metres, are used.

Current designs of birds are battery-powered, and comprise a relatively heavy body which is suspended beneath the streamer, and which has a pair of laterally projecting wings (hence the name "bird"), one on each side. The combination of streamer and birds is arranged to be neutrally buoyant, and the angle of attack of both wings is adjusted in unison from time to time to control the depth of the streamer.

Birds in accordance with these current designs suffer from a number of disadvantages. Because they are battery-powered, the batteries can run out before the survey is completed, necessitating either retrieval of the streamer for battery replacement, or deployment of a work boat to replace the battery in the water. The former operation is very time consuming, while the latter can be hazardous. Further, because the birds hang beneath the streamer, they produce considerable noise as they are towed through the water, which noise interferes with the reflected signals detected by the hydrophones in the streamers. The hanging of the birds from the streamers also means that the birds need to be detached each time the streamer is retrieved and re-attached each time it is re-deployed, which is again rather time consuming.

During the seismic survey, the streamers are intended to remain straight, parallel to each other and equally spaced. However, after deploying the streamers, it is typically necessary for the vessel to cruise in a straight line for at least three streamer lengths before the streamer distribution approximates to this ideal arrangement and the survey can begin. This increases the time taken to carry out the survey, and therefore increases the cost of the survey. But because of sea currents, the streamers frequently fail to accurately follow the path of the seismic survey vessel, sometimes deviating from this path by an angle, known as the feathering angle, of up to 10°. This can adversely affect the coverage of the survey, frequently requiring that certain parts of the survey be repeated. In really bad circumstances, the streamers can actually become entangled, which though rare, causes great damage and considerable financial loss. Current designs of birds can do nothing to alleviate any of these lateral streamer positioning problems.

It is therefore an object of the present invention to provide novel streamer control devices which alleviate at least some of the disadvantages of the current designs, and/or which possess more functionality than the current designs.

According to a first aspect of the present invention, there is provided a control device for controlling the position of a marine seismic streamer, the device comprising a body, two opposed control surfaces projecting outwardly from the

body, each control surface being rotatable about an axis which in use extends transversely of the streamer, and control means for adjusting the angular positions of said control surfaces, wherein said control surfaces are differentially adjustable by said control means, and the body is adapted to be mechanically coupled to the streamer so as to be capable of transmitting a lateral force thereto in any transverse direction, whereby said control surfaces can be used to control the lateral position of the streamer as well as its depth.

Advantageously, the body includes means for determining its angular position in a plane perpendicular to the longitudinal axis of the streamer.

In one embodiment of this first aspect of the invention, the body includes clamping means for clamping it to the streamer. However, in a preferred embodiment of the first aspect of the invention, for use with a multi-section streamer which includes an electric power line, the body is adapted to be mechanically and electrically connected in series between two adjacent sections of the streamer, and the control means is electrical and arranged in use to receive electric power from said electric power line.

According to a second aspect of the invention, there is provided a control device for controlling the position of a multi-section marine seismic streamer which includes an electric power line, the device comprising a body, at least two control surfaces extending outwardly from the body, each control surface being rotatable about an axis which in use extends transversely of the streamer, and control means for adjusting the angular positions of said control surfaces, wherein the body is adapted to be mechanically and electrically connected in series between two adjacent sections of the streamer, and the control means is electrical and arranged in use to receive electric power from said electric power line.

In one implementation of this second aspect of the invention, said two control surfaces are arranged to extend generally horizontally in use, and are adjustable in unison by the control means to control the depth of the streamer, the control device further comprising two additional control surfaces which extend in opposite

directions and substantially at right angles to said two control surfaces and which are adjustable in unison by the control means independently of said two control surfaces to control the lateral position of the streamer. In this implementation, the lower of the additional control surfaces is preferably heavier than the upper one.

When the streamer also includes a control line, then both in the preferred embodiment of the first aspect of the invention and in the second aspect of the invention, the control means is preferably arranged in use to receive control signals from the control line.

The control means preferably includes at least one electrical motor, and may also include means for sensing the angular position of one or more of the control surfaces.

Conveniently, said two control surfaces rotate about a common axis.

Advantageously, each of said control surfaces comprises a respective wing-like member which is swept back with respect to the direction of tow of the streamer.

Preferably, said control surfaces are releasably secured to the body, which may be adapted to be non-rotatably coupled to the streamer.

The invention will now be described, by way of example only, with reference to the accompanying drawings, of which:

Figure 1 is a somewhat schematic representation of first embodiment of a streamer control device in accordance with the present invention;

Figure 2 is a simple schematic of a control system forming part of the streamer control device of Figure 1;

Figures 3 to 5 illustrate the operation of the streamer control device of Figure 1; and

Figure 6 is a schematic representation of a second embodiment of a streamer control device in accordance with the present invention.

The streamer control device, or "bird", of Figure 1 is indicated generally at 10, and comprises an elongate streamlined body 12 adapted to be mechanically and electrically connected in series in a multi-section marine seismic streamer 14 of the kind which is towed by a seismic survey vessel and which is used, in conjunction with a seismic source also towed by the vessel, to conduct seismic surveys, as briefly described hereinbefore. To permit such connection, each end of the body 12 is provided with a respective mechanical and electrical connector 16, 18, these connectors being complementary to, and designed to interconnect with, streamer end connectors 20, 22 respectively which are normally used to join together adjacent sections 14a and 14b of the streamer 14.

The bird 10 is provided with two opposed control surfaces, or wings, 24, which project horizontally outwardly from the body 12 and which are independently rotatable about a common axis extending substantially perpendicularly through the longitudinal axis of the body. Rotation of the wings 24 is effected under the control of a control system 26 sealingly housed within the body 12. The wings 24 are generally ogival (ie rounded) and swept back with respect to the direction of tow of the streamer 14 (which direction is indicated by the arrow 28), in order to reduce the possibility of debris becoming hooked on them. To facilitate their rapid removal and re-attachment, the wings 24 are secured to body 12 by a quick-release attachment 30.

As mentioned hereinbefore, the streamer 14 includes hydrophones distributed along its length; it also includes control and conversion circuitry for converting the outputs of the hydrophones into digital data signals, longitudinally extending control and data lines for conducting control and data signals to and from the control and conversion circuitry, and electrical power supply lines for supplying electrical power from the vessel to the circuitry. All these lines are coupled together from the streamer section 14a to the streamer section 14b via respective corresponding lines

32 which extend through the body 12 of the bird 10 between the connectors 16, 18. Additionally, the control system 26 is connected to receive control signals and electric power from respective ones of the lines 32.

The greater part of the length of the body 12 of the bird 10 is flexible, the only rigid parts being the connectors 20, 22, and a short central section which houses the control system 26 and from which the wings 24 project. This central section is kept as short as possible, typically around 40 cm, so that once the wings 24 have been detached from the body 12, the streamer 14 can be wound onto and unwound from the large drum used for storing the streamer, with the body 12 still connected in the streamer. The quick-release attachment 30 permits the removal and attachment of the wings 24 to be at least partly automated as the streamer 14 is reeled in and out during the survey.

The reason for providing the elongate flexible parts of the body 12 is to provide enough length for the inclusion of one or more hydrophones or hydrophone groups, should this be necessary to preserve a desired uniform hydrophone spacing along the length of streamer 14. If no hydrophones need to be included, the flexible parts of the body 12 can be omitted altogether.

The control system 26 is schematically illustrated in Figure 2, and comprises a microprocessor-based control circuit 34 having respective inputs 35 to 39 to receive control signals representative of desired depth, actual depth, desired lateral position, actual lateral position and roll angle of the bird 10 (ie the angular position of the body 12 in a plane perpendicular to the longitudinal axis of the streamer 14). The desired depth signal can be either a fixed signal corresponding to the aforementioned 10 metres, or an adjustable signal, while the actual depth signal is typically produced by a depth sensor 40 mounted in or on the bird 10. The lateral position signals are typically derived from a position determining system of the kind described in our US Patent No 4,992,990 or our International Patent Application No WO9621163. The roll angle signal is produced by an inclinometer 42 mounted within the bird 10.

The control circuit 34 has two control outputs 44, 46, connected to control respective electrical stepper motors 48, 50, each of which is drivingly connected to a respective one of the wings 24. The stepper motors 48, 50 have respective outputs at which they produce signals representative of their respective current angular positions (and therefore of the current angular positions of the wings 24), which outputs are connected to respective control inputs 52, 54 of the control circuit 34.

In operation, the control circuit 34 receives between its inputs 35 and 36 a signal indicative of the difference between the actual and desired depths of the bird 10, and receives between its inputs 37 and 38 a signal indicative of the difference between the actual and desired lateral positions of the bird 10. These two difference signals are used by the control circuit 34 to calculate the roll angle of the bird 10 and the respective angular positions of the wings 24 which together will produce the necessary combination of vertical force (upwardly or downwardly) and lateral force (left or right) required to move the bird 10 to the desired depth and lateral position. The control circuit 34 then adjusts each of the wings 24 independently by means of the stepper motors 48, 50, so as to start to achieve the calculated bird roll angle and wing angular positions.

Figures 3 to 5 illustrate the operation of the bird 10 in the case where the streamer 14 is slightly heavy (slightly negative buoyancy), and the bird 10 thus needs to produce lift to maintain the streamer at the desired depth. This lift is produced by the flow of the water over the wings 24 of the bird 10, resulting from the 5 knot towing speed of the streamer 14 through the water, and can be changed by changing the angle of attack of the wings with respect to the flow. The magnitude of the lift required for the situation envisaged by Figure 3 is indicated by the length of the arrows 60.

If the streamer 14 now needs to be moved laterally to the right (as viewed in Figures 3 to 5), the angular position of the left wing 24 of the bird 10 is first adjusted to increase its lift, while the angular position of the right wing is adjusted to decrease its lift, as represented by the length of the arrows 64 in Figure 4, thus causing the bird 10 to roll clockwise from the position shown in Figure 3 to the position shown in

Figure 4. This clockwise roll continues until the bird 10 reaches the steady state condition shown in Figure 5, where it can be seen that the vertical component of the lift produced by the wings 24, indicated by the arrows 66, is equal to the lift represented by the arrows 60 of Figure 3 required to maintain the streamer 14 at the desired depth, while the much larger horizontal component, represented by the arrows 68, moves the streamer 14 to the right.

While adjusting the angular positions of the wings 24 of the bird 10, the control circuit 34 continuously receives signals representative of the actual angular positions of the wings from the stepper motors 48, 50, as well as a signal representative of the actual roll angle of the bird from the inclinometer 42, to enable it to determine when the calculated wing angular positions and bird roll angle have been reached. And as the aforementioned difference signals at the inputs 35 to 38 of the control circuit 34 reduce, the control circuit repeatedly recalculates the progressively changing values of the roll angle of the bird 10 and the angular positions of the wings 24 required for the bird and streamer reach the desired depth and lateral position, until the bird and streamer actually reach the desired depth and lateral position.

The body of the bird 10 does not rotate with respect to the streamer 14, and thus twists the streamer as it rolls. The streamer 14 resists this twisting motion, so acting as a kind of torsion spring which tends to return the bird 10 to its normal position (i.e. with the wings 24 extending horizontally). However, this spring returning action, though beneficial, is not essential, and the bird 10 can if desired be designed to rotate to a certain extent with respect to the axis of the streamer 14.

The second embodiment of the streamer control device or bird of the present invention is indicated at 10a in Figure 6, and comprises an elongate streamlined body 12a adapted for in-line connection in the streamer 14 in a manner very similar to the body 12 of the bird 10. The bird 10a is provided with two horizontally-extending quick-release wings 24a generally similar to, but substantially smaller in area than, the wings 24 of the bird 10, and with two vertically-extending quick-release additional wings 70. The additional wings 70 are generally similar in shape

and area to the wings 24 of the bird 10, but the lower one is heavier than the upper one so as to tend to maintain the additional wings aligned with the vertical: this can be achieved, for example, by incorporating a weight in the former and a buoyancy bulb in the latter.

The wings 24a are rotatable in unison about their horizontally-extending axis by an electric stepper motor (not shown) similar to the motor 48, while the additional wings 70 are rotatable in unison about their vertically-extending axis by an electric stepper motor (not shown) similar to the motor 50, these motors being independently controllable by a control circuit (not shown) analogous to the control circuit 34. The control circuit and the motors of the bird 10a form the basis of a control system generally similar to the control system 26 of the bird 10, in particular in that it receives control signals and power from the streamer 14. The principal differences between the control system 26 and the control system of the bird 10a are that in the latter, the inclinometer 42 is not required, and the algorithm used to calculate the respective common angular positions of the wings 24a and the respective common angular positions of the additional wings 70 is much simplified, by virtue of the fact that the wings 24a control depth only while the additional wings 70 independently control lateral position only.

It will be appreciated that the birds 10 and 10a have several important advantages with respect to prior art birds. Their in-line connection in the streamer 14 not only reduces the noise they generate as the streamer is towed through the water, but also enables them to derive power and control signals via the streamer and so obviates the need for batteries. But most importantly, they enable the horizontal position of the streamer 14 to be controlled, and not just its depth.

Another significant advantage of the birds 10 and 10a is that by virtue of the shortness of the stiff parts of their respective bodies 12, 12a and the easily detachable wings 24 or 24a and 70, they do not need to be removed from the streamer 14 during winding and unwinding. This saves a considerable amount of time when carrying out the seismic survey.

Many modifications can be made to the birds 10 and 10a. In particular, the bird 10 still has its principal advantage, viz the provision of lateral control as well as depth control, if it is externally clamped to the streamer 14 rather than connected in series in it (in which case it can be battery powered and can receive control signals in the same manner as prior art birds, or it can receive power and control signals from the streamer via a suitable transformer). Furthermore, the wings 24 of the bird 10 can be staggered slightly along the length of the body 12, in order to provide slightly more room for their respective drive trains; the wings 24a can be similarly staggered with respect to the wings 70, for analogous reasons.

Finally, the bird 10, by virtue of its adaptation for in-line connection in its streamer, still maintains a major advantage over prior art birds if it is simplified to control only the depth of the streamer, rather than the depth and lateral position.

CLAIMS

1. A control device for controlling the position of a marine seismic streamer, the device comprising a body, two opposed control surfaces projecting outwardly from the body, each control surface being rotatable about an axis which in use extends transversely of the streamer, and control means for adjusting the angular positions of said control surfaces, wherein said control surfaces are independently adjustable by said control means, and the body is adapted to be mechanically coupled to the streamer so as to be capable of transmitting a lateral force thereto in any transverse direction, whereby said control surfaces can be used to control the lateral position of the streamer as well as its depth.
2. A control device as claimed in claim 1, wherein the body includes means for determining its angular position in a plane perpendicular to the longitudinal axis of the streamer.
3. A control device as claimed in claim 1 or claim 2, wherein the body includes clamping means for clamping it to the streamer.
4. A control device as claimed in claim 1 or claim 2, for use with a multi-section streamer which includes an electric power line, wherein said body is adapted to be mechanically and electrically connected in series between two adjacent sections of the streamer, and the control means is electrical and arranged in use to receive electric power from said electric power line.
5. A control device for controlling the position of a multi-section marine seismic streamer which includes an electric power line, the device comprising a body, at least two control surfaces extending outwardly from the body, each control surface being rotatable about an axis which in use extends transversely of the streamer, and control means for adjusting the angular positions of said control surfaces, wherein the body is adapted to be mechanically and electrically connected in series between

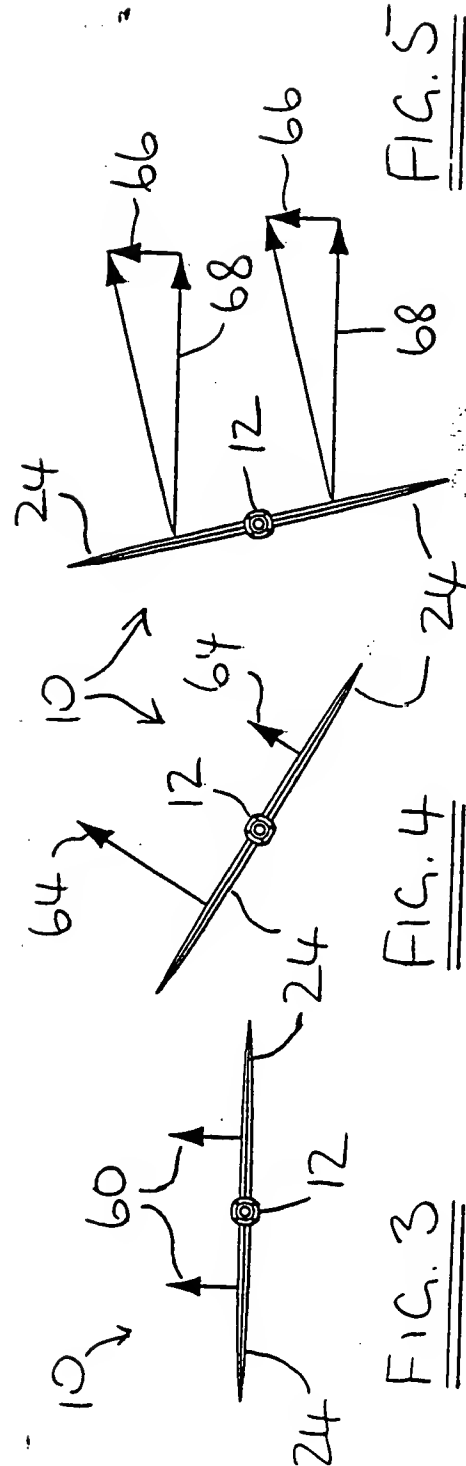
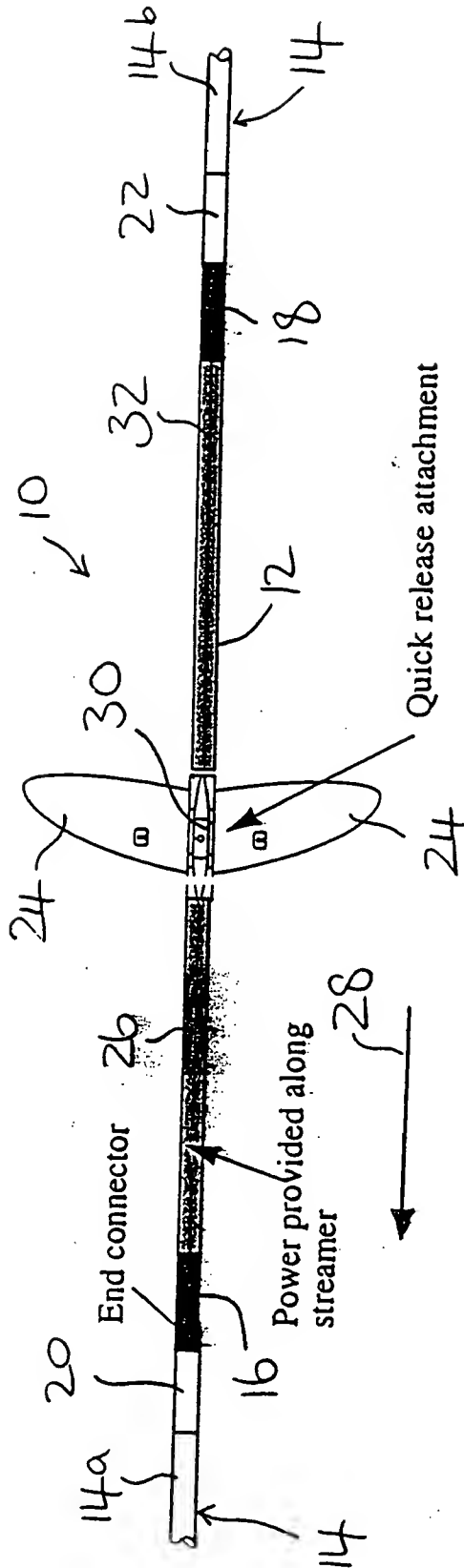
- two adjacent sections of the streamer, and the control means is electrical and arranged in use to receive electric power from said electric power line.
6. A control device as claimed in claim 5, wherein said two control surfaces are arranged to extend generally horizontally in use, and are adjustable in unison by the control means to control the depth of the streamer, the control device further comprising two additional control surfaces which extend in opposite directions and substantially at right angles to said two control surfaces, and which are adjustable in unison by the control means independently of said two control surfaces to control the lateral position of the streamer.
 7. A control device as claimed in claim 6, wherein the lower of the additional control surfaces is heavier than the upper one.
 8. A control device as claimed in any one of claims 4 to 7, for use with a streamer which also includes a control line, wherein the control means is arranged in use to receive control signals from the control line.
 9. A control device as claimed in any one of claims 4 to 8, wherein said control surfaces are releasably secured to the body.
 10. A control device as claimed in claim 9, wherein the body is adapted to be wound onto a streamer drum while still connected in the streamer.
 11. A control device as claimed in any preceding claim, wherein said control means includes at least one electrical motor.
 12. A control device as claimed in any preceding claim, wherein the control means includes means for sensing the angular position of one or more of the control surfaces.
 13. A control device as claimed in any preceding claim, wherein said two control surfaces rotate about a common axis.

14. A control device as claimed in any preceding claim, wherein each of the control surfaces comprises a respective wing-like member which is swept back with respect to the direction of tow of the streamer.

15. A control device as claimed in any preceding claim, wherein the body is adapted to be non-rotatably coupled to the streamer.

16. A control device for controlling the position of a streamer, the device being substantially as herein described with respect of Figures 1 to 5 of the accompanying drawings.

17. A control device for controlling the position of a streamer, the device being substantially as herein described with respect of Figures 1 to 5, as modified by Figure 6, of the accompanying drawings.



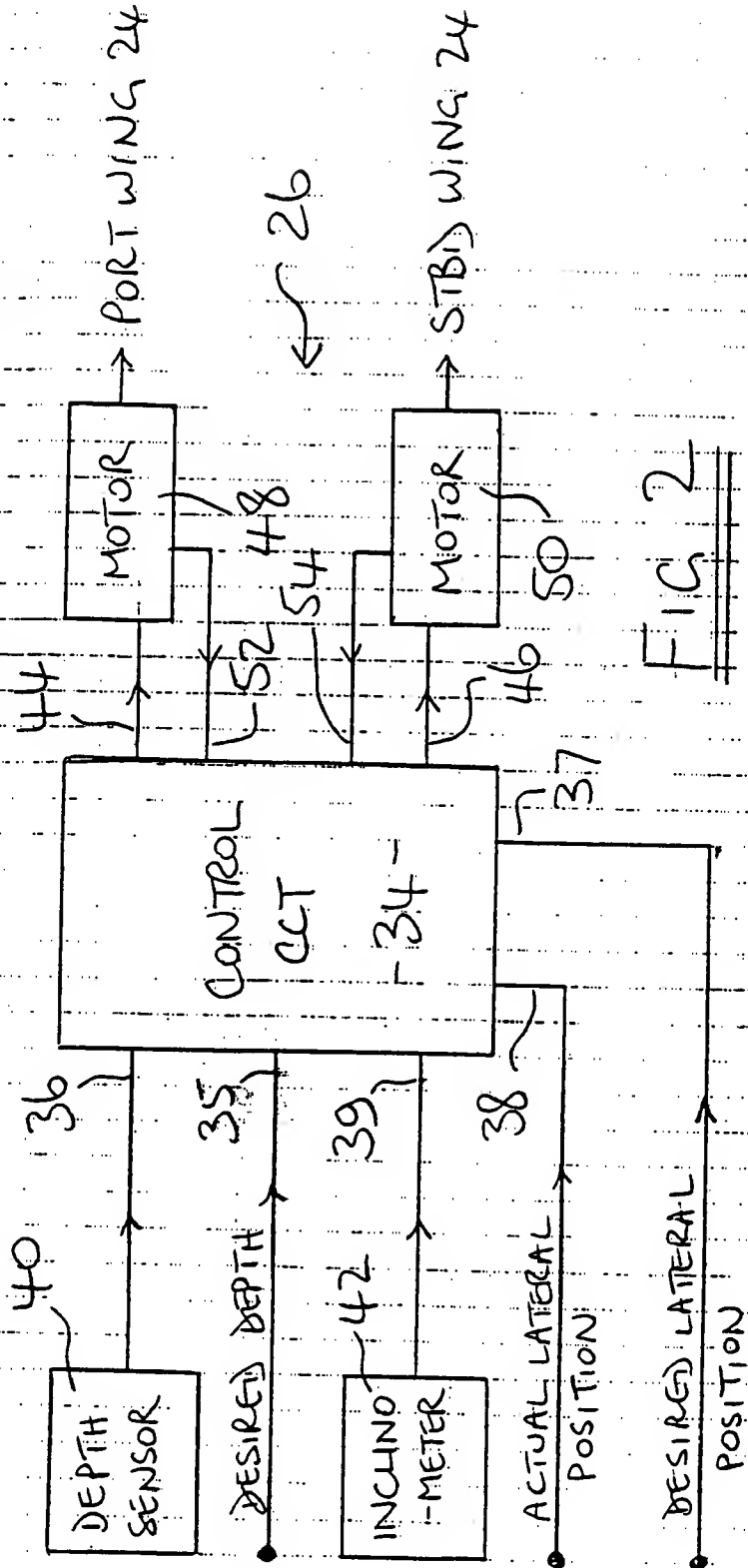


FIG 2

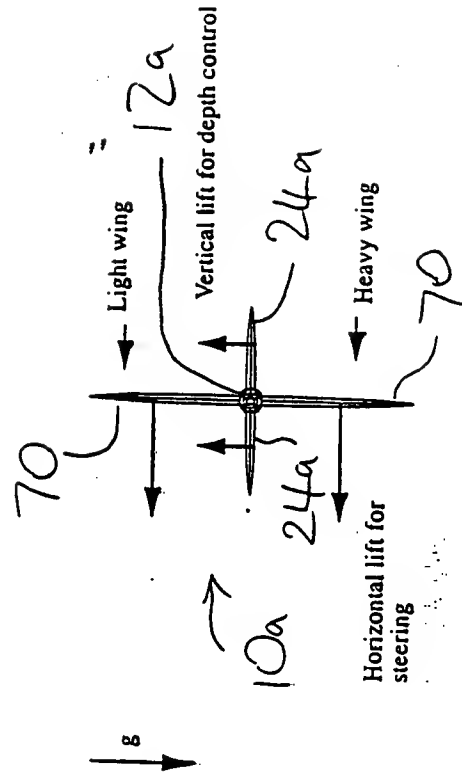


FIG 6